Flight Validation of Instrument Processing Onboard Earth Observing One: A Status Report

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Goals

- Baseline: Demonstrate that hyperspectral data can be used to synthesize multispectral data onboard.
  - Specific: Demonstrate that Hyperion Hyperspectral data can be used to synthesize OLI multispectral data onboard.
- Stretch: Demonstrate other technology push onboard processing techniques
  - Specific: Bayesian Thresholding, Support Vector Machine Learning, Random Decision Forest

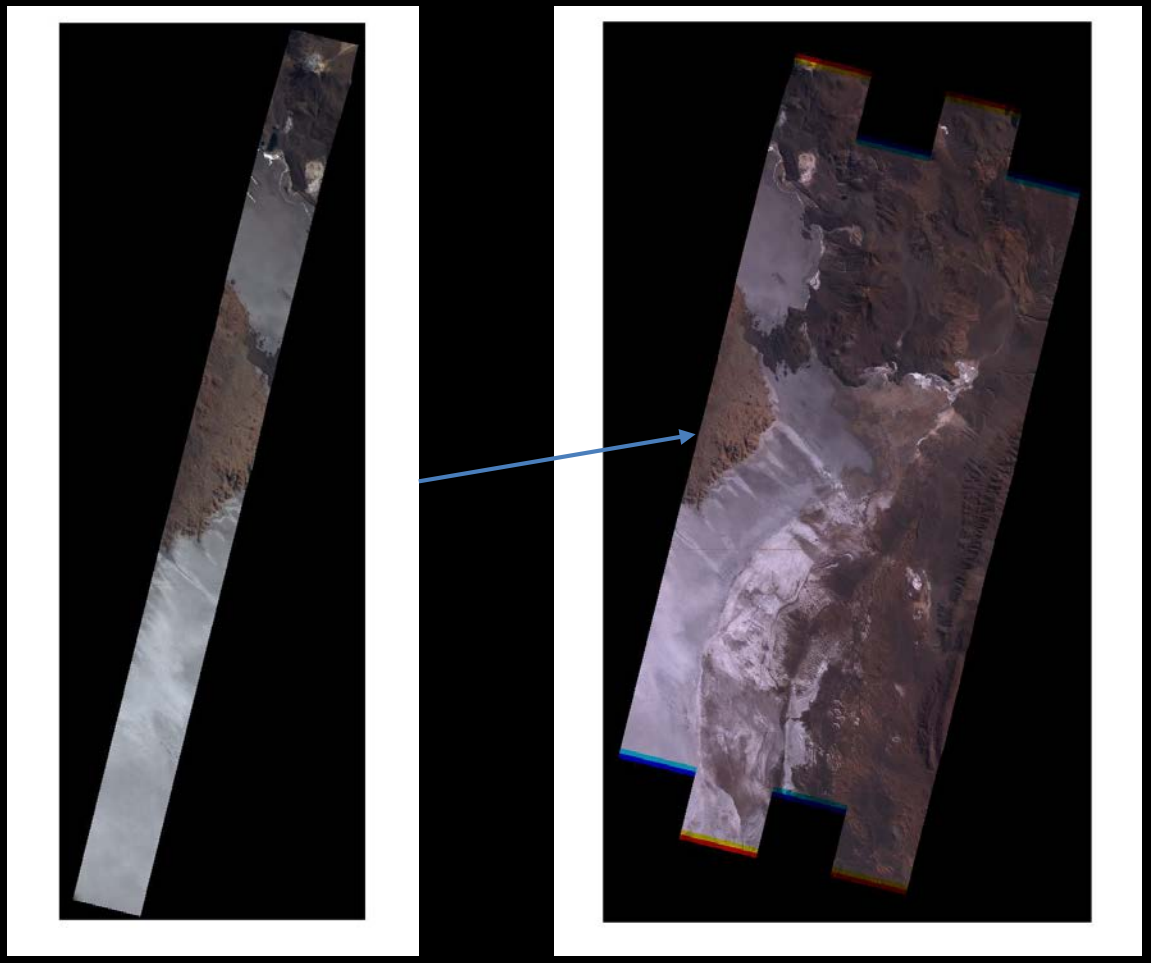
Approach

- Utilize existing capabilities
  - Autonomous Sciencecraft (ASE) Flight Software [Chien et al. 2005] in use to operate EO-1 2004 – present.
  - ASE includes
    - Onboard Hyperion Data Analysis
      - Uses Microtel Band stripping
    - Onboard mission re-planning
    - Onboard execution

ASE Instrument Data Processing

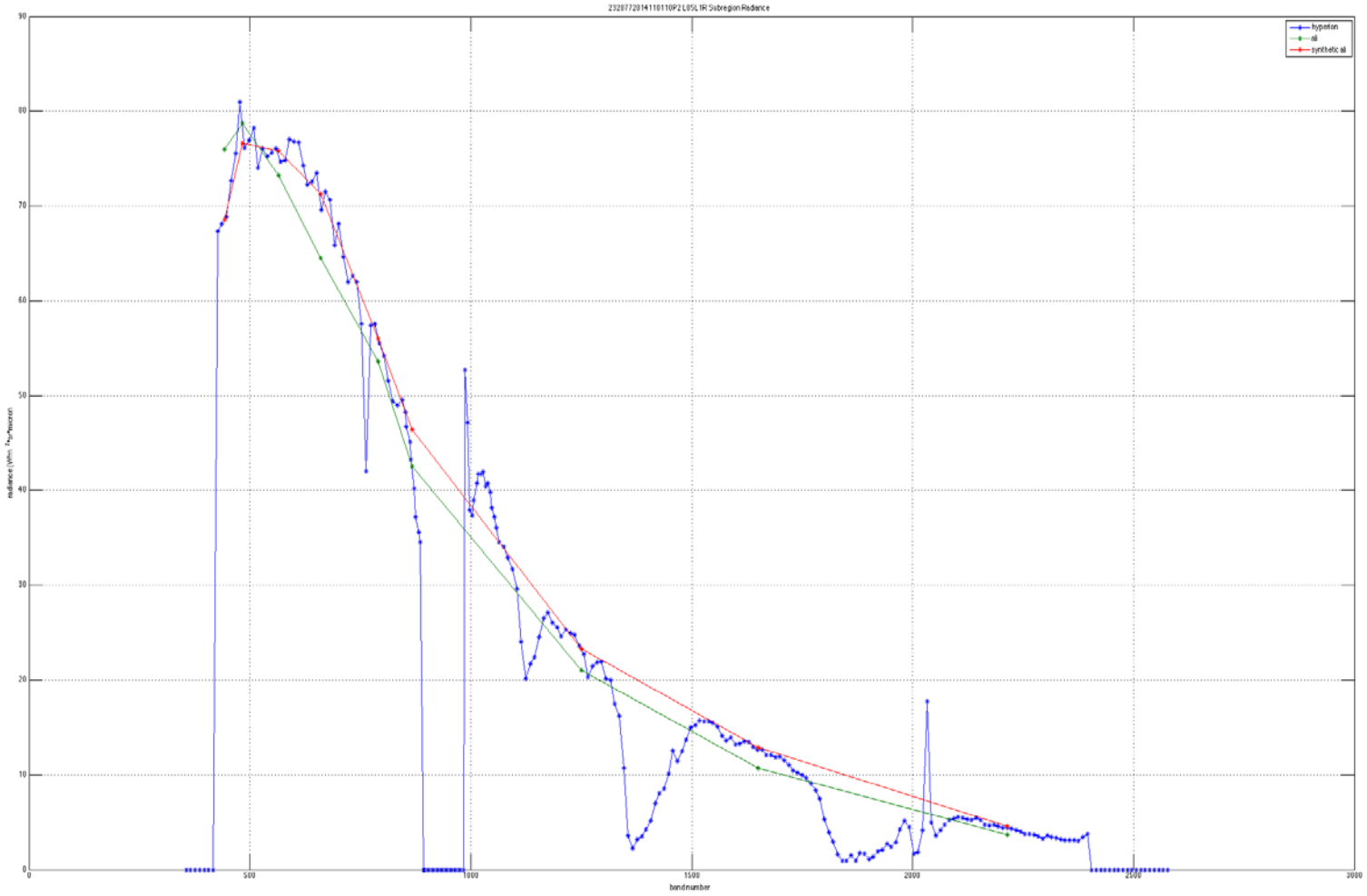
- Band stripping capability
  - Implemented by Microtel
  - Enables band stripping of 12 Hyperion Bands
    - Must include at least 1 SWIR and 1 VNIR band
    - Strips out 1024 x 256 pixel image
    - Requires ~ 20 minutes to strip
  - ASE provides
    - Standard interface for accessing the stripped data
    - Standard interface to output data product
    - Data is then downlinked via S-band
      - Automatic Eng. DL is option as is file download

Sample Hyperion → ALI



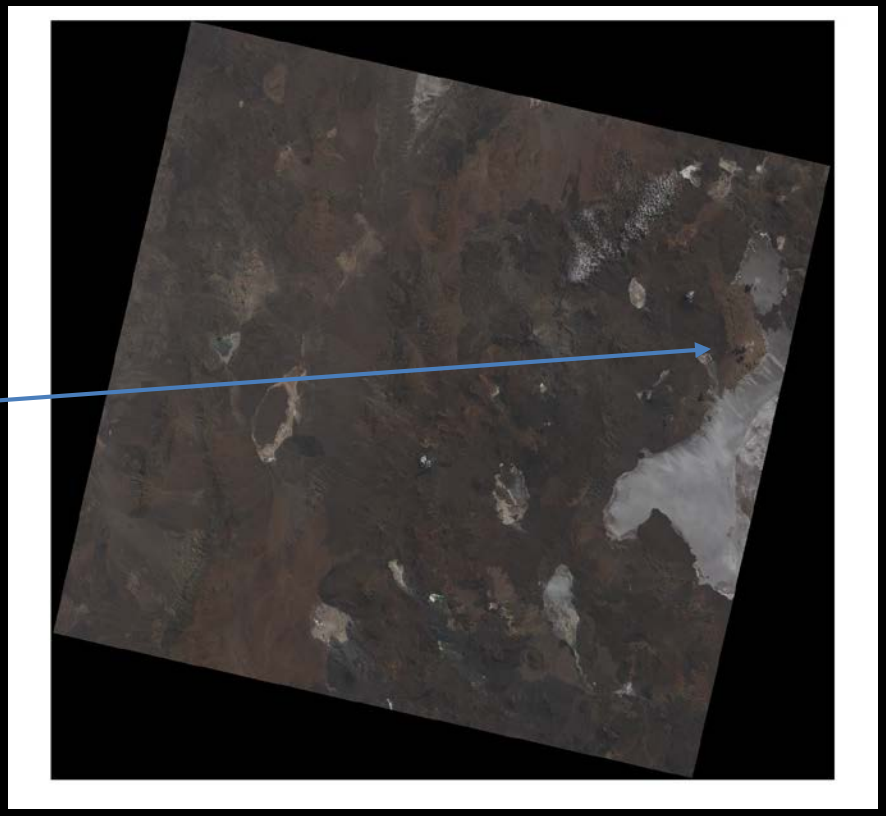
(L) Hyperion Synthesized to ALI (R) ALI
Arizaro Desert, Argentina

Radiance Subregion comparison



Sample Hyperion → OLI

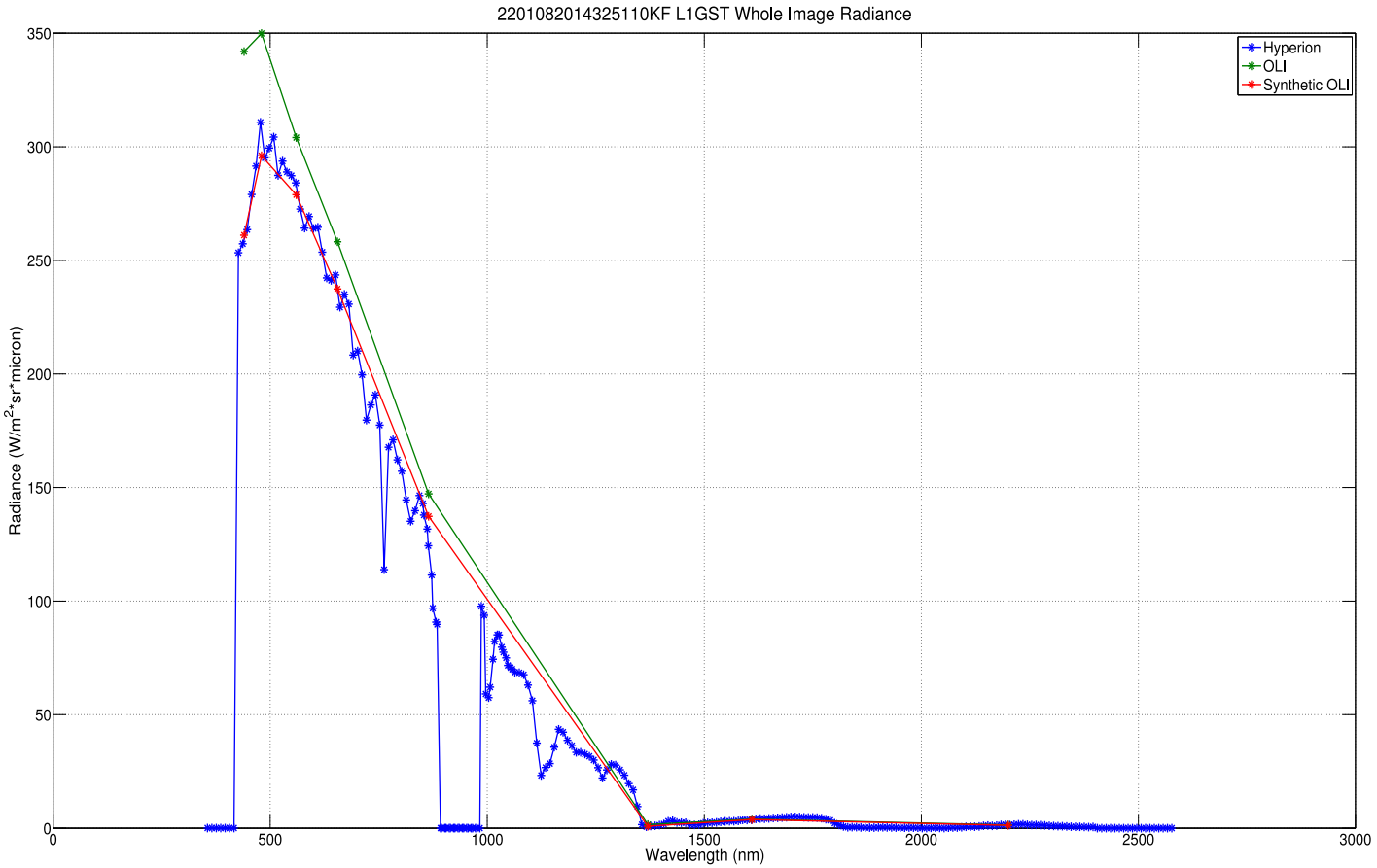
Hyperion→OLI



OLI

Arizaro Desert, Argentina

OLI Radiance Subregion Comparison

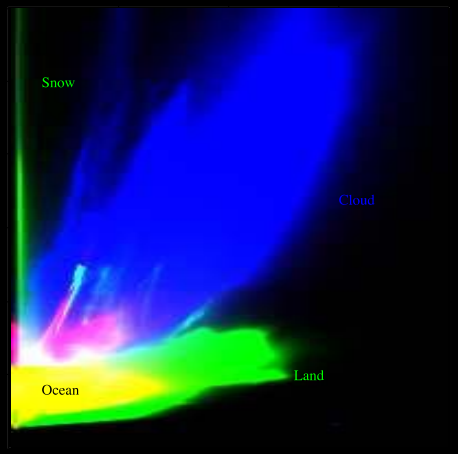


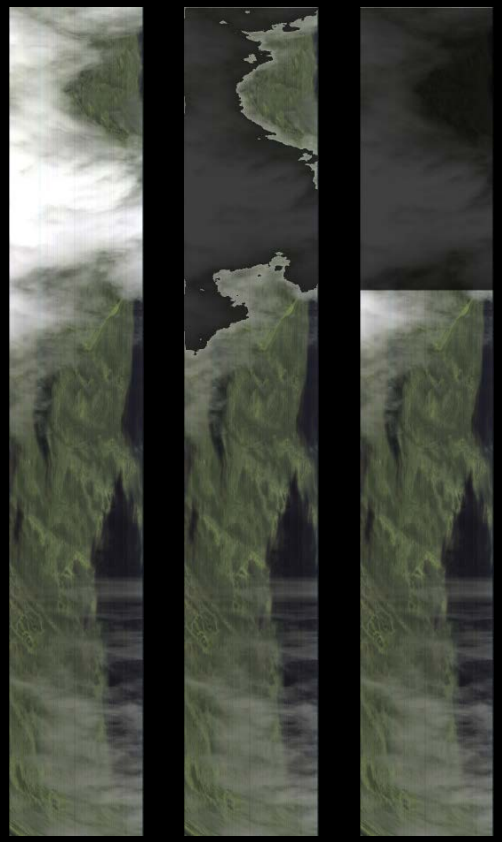
Not nearly as clean as ALI due to geo-correction.

OTHER INSTRUMENT PROCESSING TECHNIQUES

Thresholding Cloud Screening

- Computes optimal thresholds in multi-dimensional spectral space given:
  false negative,
  false positive costs by modeling spectral distribution of pixels
- Previously used on Aviris NG (Thompson et al. 2014 TGARS)



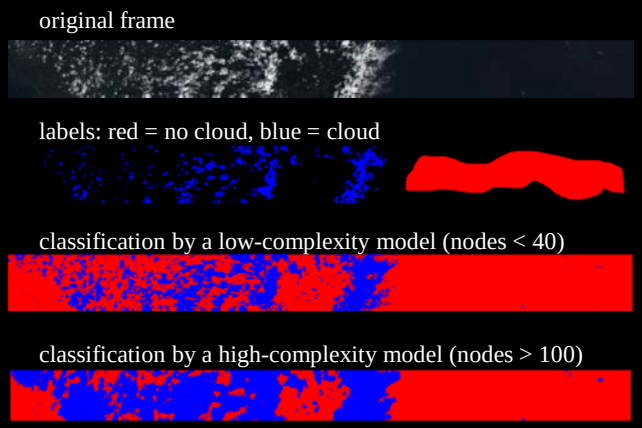


Aviris-NG screened data using 0.45 μm and 1.65 μm bands

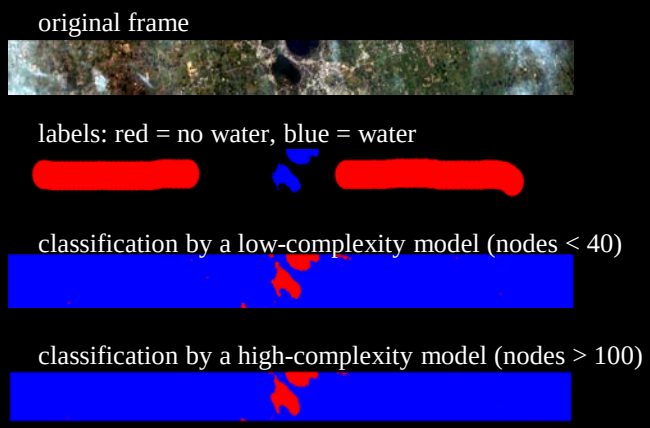
POC: David Thompson/JPL

TextureCam: Random Decision Forests

- **Motivation:** Onboard cloud screening can assist with image triage and prioritization for downlink. Other classification problems can be addressed by RDFs.
- **Problem:** Previous methods have generated larger RDFs, we would like to see if compact RDFs can classify well.
- **Solution:** A forest classification engine designed to classify surfaces in images based on visual appearance.
- TextureCam provides automated cloud cover assessment in EO-1 Hyperion data.



Cloud Classification

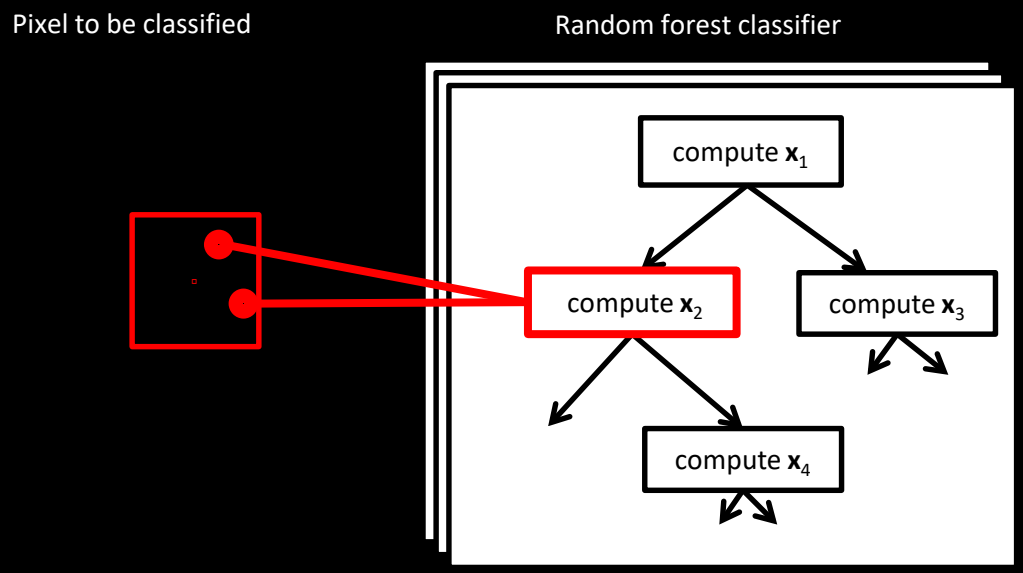


Surface Water Extent Classification

POC: U. Rebbapragada, A. Altinok, D. Thompson /JPL

How it works

- We trained the system on manually-labeled images from ground data set.
- At runtime, the classifier calculates visual attributes by analyzing a local neighborhood around the classified pixel.
- A decision forest aggregates class probability estimates from multiple independent decision trees.



References: Thompson et al., i-SAIRAS 2012; Wagstaff et al., Geosci. Res. Lett. 2013; Bekker et al., *Astrobiology* 2014; Altinok et al. 2015 JFR.

Visual Salience

- Run sliding window across image
- For each window,
  - Compute statistical deviation of center pixel from its surroundings

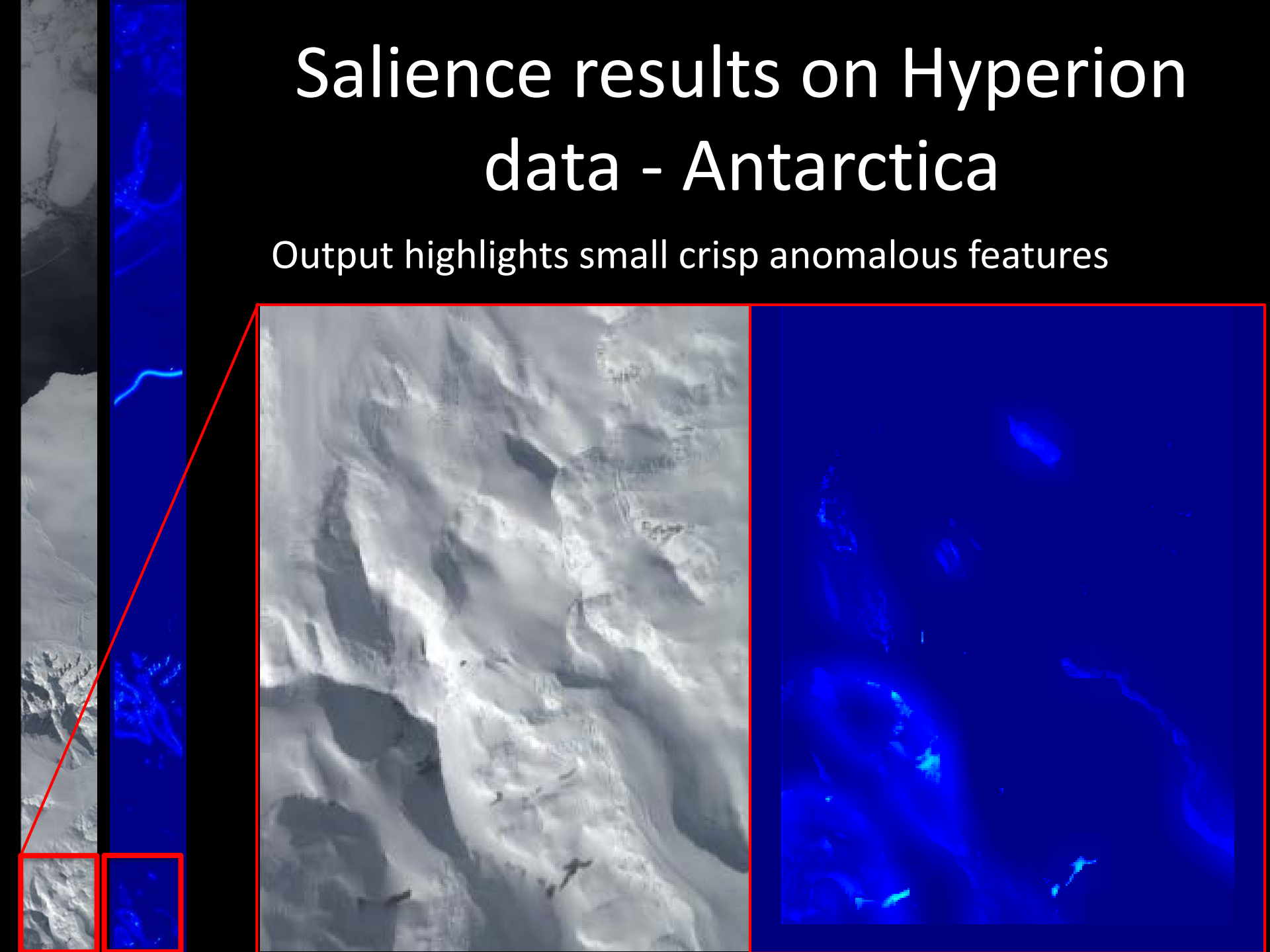
$$S_P(x, y, w) = \frac{1}{M} \sum_i |p_{x,y} - i| P_w(i),$$

- Salience values can be used to prioritize images or crop out subsets with high salience
- Visualize result (salience map) with heat map

Reference: Wagstaff et al., TIST 2012

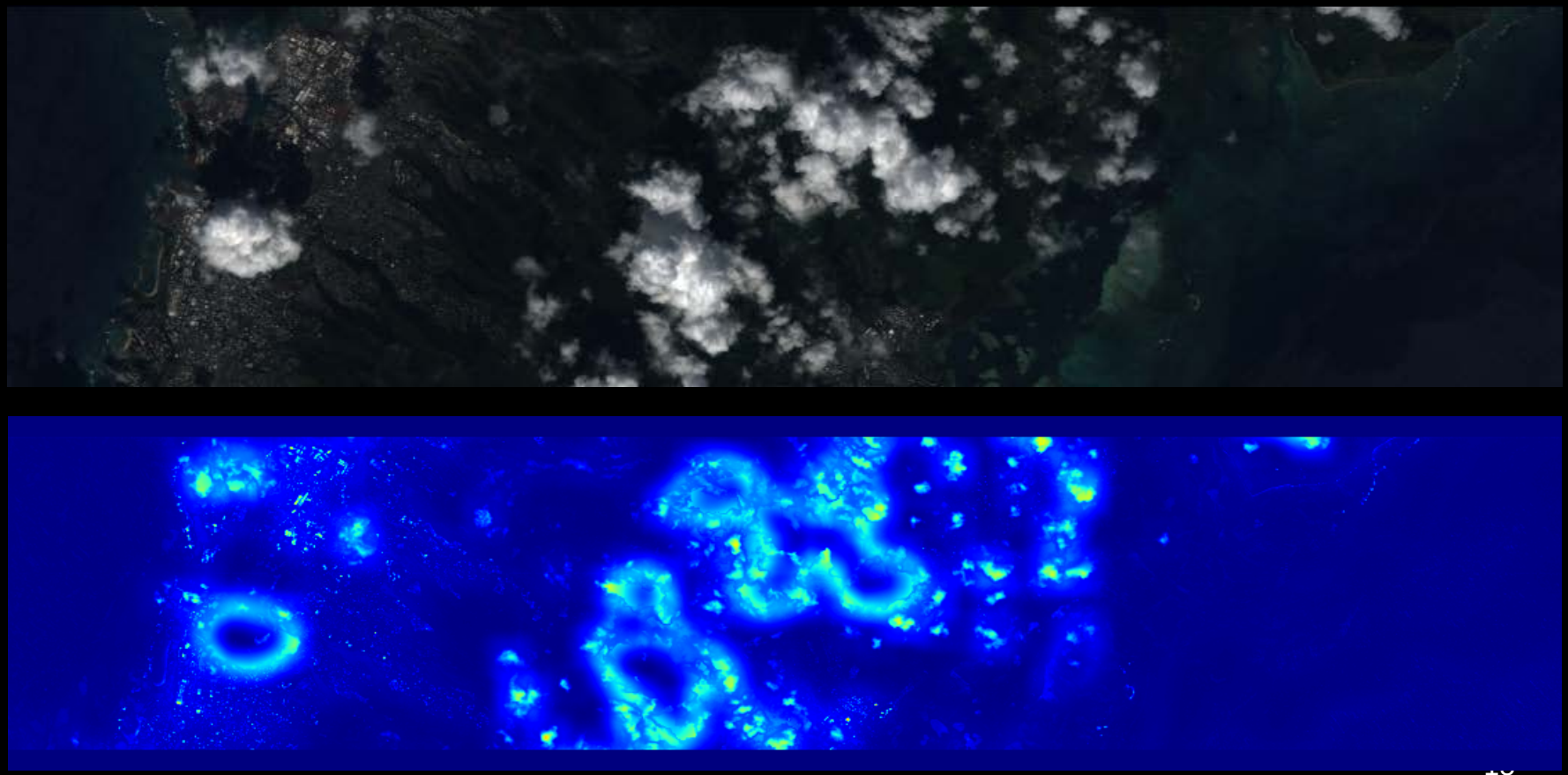
Salience results on Hyperion data - Antarctica

Output highlights small crisp anomalous features



Detects cloud edges and buildings

- Hawaii



North of Lake Mendota –

Detects isolated snowy areas and isolated cleared areas

Status

- EO-1 FSW Upload 29 Sep – 4 Oct 2016.
- Jump to new code Monday 10 October 2016.
- Nominal operations follow.
- 1st test scene Arizaro, Argentina scheduled for 14 October 2016.

Conclusions

- EO-1/ASE has excellent supporting infrastructure to flight validate OLI product generation onboard
  - Flight tests for OLI and ALI generation onboard are under way!
- Additional technology push onboard processing technologies will simultaneously be demonstrated
  - Threshold-based cloud screening
  - TextureCam / Random Decision Forest
  - Visual Salience